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February 1991

Agricultural Research

Eye in the Sky: Checking Crop Health

Story on Page 4

Remote Sensing for Agriculture . . . Is the Sky the Limit?

One of the biggest users of satellite remote sensing on a day-to-day basis could be agriculture. Right now, that's not the case—largely because of what happens to satellite data once it's reached the ground. However advanced the satellites may be, their transmissions to Earth are still processed and distributed in a way that's generally out of tune with the information needs of modern farm and ranch management.

Not that anything is wrong with the data itself. Thanks to an extensive body of ongoing research by remote sensing scientists, satellite measurements of visible and infrared reflectance from soil, water, and plants can reveal many subtle but significant changes in forest, range, and cropland conditions. Indeed, our technical ability to detect and monitor incipient droughts, insect infestations, and plant diseases from space is not an issue.

The problem with satellite-based remote sensing, from a farm/ranch management standpoint, is one of getting the right information to the right place at the right time. It's a matter of limited resources within the public and private organizations that handle remote sensing data.

Remote sensing satellites transmit massive amounts of data covering hundreds to thousands of square miles per minute. The normal turnaround time—the time it takes to process the raw data and deliver it to a customer—is several weeks. It used to be several months.

Can things be handled faster? Perhaps, but that means more staff, more processing equipment, more links in the data delivery network, and more money. Sorting through all the numbers and matching them to the daily needs of individual farmers and ranchers is a lot to ask, especially when other markets are ready to buy more generalized and less time-related information.

So where does this leave farmers and ranchers? Will they ever have timely access to remote sensing data? They will, but not the data from satellites—at least not for the rest of this century. Instead, it looks like video cameras in low-flying aircraft may be the way to go.

This month's cover story by Jim De Quattro describes ARS research in Weslaco, Texas, on remote sensing with low-altitude video (LAV).

Like the multispectral radiometers in satellites, specially filtered video cameras in aircraft detect selected frequencies of visible light and infrared energy reflected from the ground. Unlike the satellite data, video-recorded images based on the selected frequencies can be viewed and analyzed as soon as the plane lands.

The developments at Weslaco are more than promising: Clearly, the high-resolution video recorder and synchronized three-camera system being tested there could be considered a prototype. It shouldn't be long before such systems are routinely providing farmers and ranchers with reliable remote sensing data in a timely manner.

Does the enormous potential of airborne video suggest that farmers and ranchers forget about remote sensing data from satellites? That depends on the type of data needed. In terms of farm and ranch management, the answer is no in some ways and yes in others.

Most satellites scan wide strips of land from a carefully planned sequence of orbits that eventually blanket the globe. Naturally, this allows them to monitor agricultural conditions on regional and even continental scales—an essential capacity for certain statistical compilations and production estimates. It can also help individual farmers and ranchers prepare for droughts, insect infestations, plant diseases, and other problems headed their way.

Low-altitude video, on the other hand, offers site-specific data almost immediately and at comparatively little expense. Furthermore, LAV flights can be more readily scheduled to suit demand and can be repeated as often as necessary.

And the kinds of data that LAV offers are increasing. Researchers at Weslaco are finding more and more frequencies in the near-infrared and infrared bands that can be useful in assessing crop, range, and forest conditions.

Another advantage of low altitude video comes with the obvious ability of planes to closely follow streams and rivers winding through long stretches of farmland. The Red River running between the Dakotas and Minnesota, the Platt River cutting across Nebraska, and the Rio Grande marking our southwest border are classic examples of such terrain. Monitoring these and other waterways and the fertile valleys they serve could become an LAV speciality important to local water quality programs and agricultural concerns alike.

It appears that LAV will be more useful to farmers and ranchers on a day-to-day basis and that satellite data is best for long-range and broad-based land management decisions. Perhaps the two will compete for agricultural clients in the future if or when satellite data is handled more quickly. In the meantime, LAV and satellite-based remote sensing have their respective roles to play. They complement each other quite well, and more research is needed on the agricultural applications of both.—**Stephen Carl Miller**, ARS.

Agricultural Research

Cover: Lower Rio Grande Valley, Texas, farm fields as seen by infrared-color video from about 4,000 feet altitude. Diseased, infested, or nutrient-starved crops can be identified quickly with a single overflight. Story on page 4. (K-3957-1)

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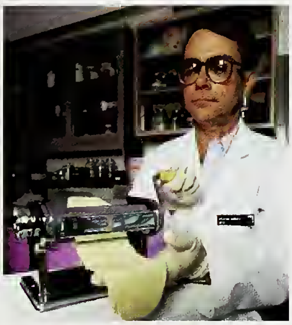

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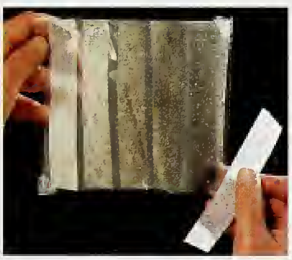

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Airborne Video
A Ride in ARS' Own "Air Force 1"

On a bright clear morning, pilot Rene Davis is cruising at 7,800 feet about 12 miles northwest of Weslaco, Texas. Seated behind Davis in the twin-engine Aero Commander 680S is David E. Escobar, remote sensing specialist.

The Agricultural Research Service obtained the plane in 1978, after the Drug Enforcement Administration broke up a ring of drug smugglers. Today, ARS' Davis and Escobar are using the plane to snoop on sick sorghum. It's all part of research aimed at finding whether airborne video can tell farmers, ranchers, and ag consultants what they need to know—faster and cheaper.

KEITH WELLER

Remote sensing specialist David Escobar checks infrared video scan of cropland thousands of feet below. (K-3931-16)

Escobar's eyes are riveted to a video monitor on the cabin floor beside his seat. As an agricultural landscape glides across the monitor, he suddenly spots the field he's looking for.

"Hold it right there," he calls over the engine noise.

Davis reduces the power, and the aircraft, aimed into a stiff headwind, seems to hover over the field like a gull over a beach. The TV scene on the monitor enlarges; the headwind is no match for gravity, and the plane is slowly losing altitude.

On the monitor, an elongated pink blob lies diagonally across the otherwise magenta-colored crop field.

Escobar doesn't touch any dials; there's nothing wrong with his set. The magenta color represents healthy sorghum; the pink blob is caused by chlorosis, an iron deficiency that blanches the sorghum's leaves and cuts yield.

Escobar can already see that the blob takes up at least one-third of the field. But Davis' piloting aims the cameras so Escobar can get the best possible image of the blob; he and other scientists at the lab can have a computer calculate its dimensions.

The video scene is a color-infrared composite made by combining images taped simultaneously by three cameras, each with a different light filter. The cameras, bolted to a steel frame, peer down through a porthole in the cabin floor. One camera has a near-infrared filter; the second, red; the third, yellow-green. The resulting black and white images—which appear similar to the untutored eye—feed separately into three Super-VHS recorders. A fourth recorder snares the color-infrared composite. The cover photo is an example of this.

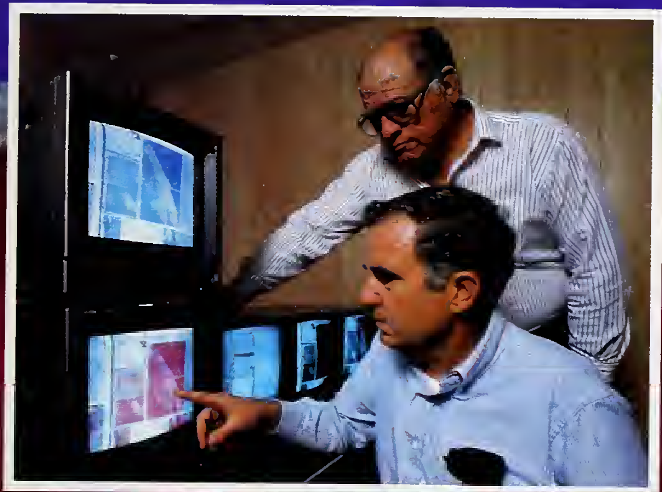
Years of studies by range scientist James H. Everitt, Escobar, and others at Weslaco's ARS Remote Sensing Research unit and elsewhere have established specific "signatures" for plant, soil, and water conditions that show up best on one or another of the three cameras and can then be interpreted in the color-infrared composite imagery.

In color-infrared, healthy vegetation typically appears as magenta. Diseased areas have dull red or brown tones—or a bright pink like the

DAVID ESCOBAR

Remaining trees show up as dark spots in this abandoned citrus orchard.

KEITH WELLER



James Everitt (foreground) and David Escobar study images of grain sorghum suffering from leaf chlorosis. (K-3931-5)

Grain sorghum field as seen from infrared video cameras. Darkest red areas are healthy plants.

Iron deficiency caused by an elevated soil pH affects about 40 percent of this field.

chlorotic sorghum. Bare areas, such as ant mounds or soil that is too salty or dry for crops, appear whitish-gray to white.

As the seconds tick, Escobar flips switches, alternating the monitor among the similar black-and-white images from the three cameras and the composite.

After 24 seconds, Escobar's seen enough. "Okay," he cues Davis, who adds power to the engines at 6,800 feet and heads the plane back to Weslaco Mid-Valley Airport.

At the Weslaco lab a few hours later, Everitt, Escobar, computer specialist Rick Villarreal, and computer aide Noel Garcia will plot the imagery on a computer. Using software called "image processing," they'll determine that chlorosis covers 41 percent of the 130-acre sorghum field. Yield from the field will be cut by 25 percent or more.

Enabling farmers to act quickly to counteract diseases and insects and to estimate probable yields are only two potential uses for this promising video technology. Already, visitors from several agricultural companies, government agencies, and growers' groups have made trips to Weslaco to see how the system works.

An Australian firm is now using the ARS scientists' basic three-camera system design to provide information for irrigation management in cotton. And it is getting high ratings from U.S. agricultural and environmental audiences interested in a faster, cheaper way to get the latest news on range, pasture, and croplands.

Everitt says farmers and ranchers may someday pop a tape into a VCR every week or so to check whether—and how fast—rice borers are spreading through sugarcane, toxic weeds are marching across the range, or sooty mold is growing on citrus

leaves that have been "slimed" by leaf-sucking insects like blackflies.

Toxic waste leakage from dumps, hail damage to crops—even mighty volcanos and tiny oysters—may someday be tracked by the kind of video system developed at Weslaco.

Everitt developed the system along with Escobar and electronics technician Juan R. Noriega. "Airborne video is ready to take off," says Everitt, "partly because the industry's recent invention of Super-VHS recorders makes for a sharper image on a screen." Super-VHS yields more than 400 lines of horizontal resolution compared with 240 lines for typical home recorders.

"But making that extra resolution useful to agriculture," he says, "has meant learning from three decades of research on interpreting aircraft and satellite data" by scientists at ARS, the National Aeronautics and Space Administration, universities, and private companies. "Aerial video won't replace aerial photography and satellite data, but it can provide a lot of information faster and cheaper."

Film for aerial photography and processing can cost $200 to $1,000 a roll; a 2-hour, reusable Super-VHS tape costs about $15. "Plus," Everitt adds, "video cameras have higher light sensitivity than film and that allows them to get better results on hazy or cloudy days.

"Since there's a video monitor right in the plane's cockpit, we can monitor the action live—we can see what we're getting while we're getting it."

Then, as with the pink blob video, Weslaco scientists can quickly convert the video images into numbers to estimate how many acres there are of—right now—about two dozen different weed, disease, crop, and soil conditions.

Recently, Everitt demonstrated the high-tech multispectral system for specialists from the Environmental Protection Agency.

"It has potential to supplement our conventional aerial photo studies," says Gordon Howard. He's based in Warrenton, Virginia, at the EPA's Environmental Photography Interpretation Center (EPIC).

DAVID ESCOBAR

From 4,000 feet above, healthy sugarcane appears solid red in field at upper left. Lighter areas within the red indicate rice borer damage and soil salinity problems. (K-3957-1)

Howard thinks the video system could help reveal leakage of chemicals from hazardous waste dumps. "If it spotted dead or dying trees or other plants near a dump, we'd check on the ground to see whether chemicals are responsible," he says.

According to Clay Lake, a project officer for EPIC in Las Vegas, Nevada, "Nothing else we've looked at is as good as what they've got at Weslaco. We're impressed with its high resolution. A system like that would give us a quicker, easier way of discovering illegal dumping and monitoring its effects on an area."

Lake believes color-infrared airborne videos could also help EPA see if illegal stream dredging or filling is destroying wetlands, direct emergency cleanup crews to oil and other pollutant spills, document cleanup at Superfund sites, and monitor how well vegetation recovers after a spill. "We've already bought one system like Weslaco's experimental one. We'd like to see one at each EPA regional office across the country," Lake reports.

From videos, investigators could get a faster, cheaper way to collect evidence and prepare reports for use in court, according to Steven Sisk, a groundwater hydrologist at EPA's National Enforcement Investigation Center in Denver.

"On board the plane," he says, "an investigator would narrate as a site is recorded on video. Back on the ground, we would digitize the images and quickly convert them into a map. The map would highlight important features, including overlays showing the site's geology and groundwater."

Your Check's in the Mail—Sooner

Mark Fuchs, a crop insurance specialist, says airborne video could enable companies to settle crop insurance claims faster after hailstorms or other disasters strike.

Fuchs works for National Crop Insurance Services, an industry trade group. Based in Overland Park, Kansas, NCIS works out policies and procedures used by claims adjusters of member firms.

Settling a claim for hail damage is often more complicated and time consuming than what happens after you dent your car fender, he explains.

"When you wreck your car, the damage is done. The car won't fix itself or suffer further damage," he says. "But with a crop field, you're looking at living organisms and it's often hard to know how well the plants will recover."

An adjuster might still be walking a field after dark—and after a big hailstorm there may be hundreds of farmers in line.

About 5 years ago, NCIS ran a pilot program using infrared aerial photography. Results were good, but the time lag from flight to photo was usually more than a week. And the photos all required visual interpretation. With digitized imagery, a computer could interpret conditions.

"Since a photo is a chemical emulsion, you need an extra step—computer scanning—to put the data on computer. Video is already electronic," he notes. "Not only does it give us visual and computer data much faster—perhaps the same day—but also the adjuster can quickly and accurately determine location and size of damaged areas.

"We still have a way to go before we can use the new technology. But a company with dependable video imagery and interpretation would have a great selling point. The farmer would get a faster response and a loss estimate based on information that he or she can literally see."

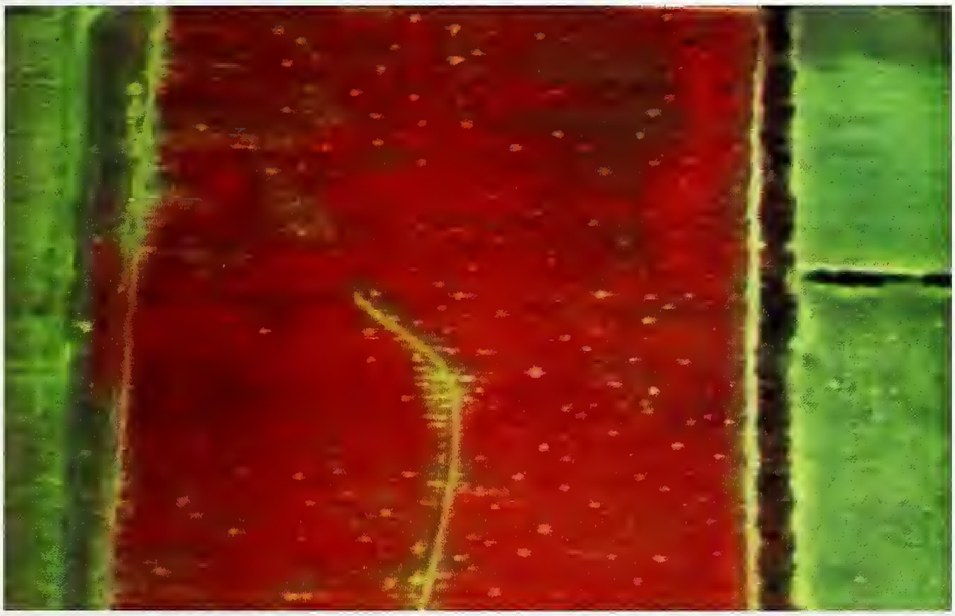
Orbiting Video?

Weslaco's airborne video may someday soar into space, according to Victor Whitehead of NASA.

"We would like to work with ARS to develop a multispectral video system mounted in the payload bay of the shuttle," he says. "Something like it could also go aboard the space station when that's built."

Among the possible uses is monitoring marine environments such as Texas' South Padre Island. There, unique oyster beds are threatened by water pollution from rapid urban development.

DAVID ESCOBAR



Harvester ant beds dot this infrared video photo of a cottonfield. Harvester ants destroy vegetation within an 8 to 10 foot circle, making the low mounds readily visible from 7,300 feet altitude. (K-3957-11)

"With multispectral video, we could also capture events like major floods and volcanic eruptions in real time," says Whitehead, a meteorologist in the Flight Science Support Office of NASA's Lyndon B. Johnson Space Center in Houston. "Our main job is helping astronauts to document their missions and to get useful imagery for a range of scientists studying natural resources and the environment."

Shuttle astronauts already use conventional video to monitor activity in the payload bay, he says. They also take photos of Earth with cameras mounted in the bay.

According to Whitehead, "multispectral video would give unlimited coverage time, and the imagery could be instantly telemetered to Earth. With film, we have to wait until the spacecraft returns."

Everitt, other ARS scientists, and NASA recently began a different study to interpret photographs taken last October by the crew of the Columbia shuttle. The pictures include the South Padre oyster beds.

The Weslaco site is ideal for cooperative studies with ARS, Whitehead notes. "The shuttle frequently flies over that area, where ARS can get ground information used to check interpretations of video or photo imagery." The U.S. space station is slated to orbit over the same latitude, he adds.

Meanwhile, Back on Earth...

Everitt says tests of the video system are being planned with the Rio Grande Valley Sugar Producers Association, which is concerned about outbreaks of rice borers. "It's

pretty hard to see anything from the ground in a big sugarcane field once the crop gets high, but we can spot borer damage from the air," he says.

By accident, the scientists recently discovered that the system can also spot a disease in another tall plant, kenaf, which grows to about 15 feet high.

Charles Cook, research geneticist at Weslaco, has some test plots of this experimental crop, which may someday become a significant source of pulp for paper and high-protein forage for cattle.

During a flight over the research plots last summer, Escobar noticed on the video monitor a dark stain that proved to be root rot. Cook hadn't known about it because the plants were too tall for the evidence to be seen from the ground.

Everitt's team often supplies video for ARS projects. For example, the team recorded video

DAVID ESCOBAR

Dark areas are brushy plants; light areas represent grass. Dry lake beds appear circular. (K-3959-11)

transects, slices of coverage several miles long and about 100 yards wide, of the agency's 197,000-acre Jornada Experimental Range in New Mexico. Scientists use the transects to study how the number and kind of range plants are influenced by escarpments—long, low natural ridges that trap rainwater in the dry climate.

Airborne video could also help map the spread of saltcedar, a shrubby tree that can, according to Jack DeLoach, "block a stream or channel and make it disappear. And it damages wildlife habitat by displacing native plants most game and songbirds prefer." Jack DeLoach is at the ARS Grassland, Soil, and Water Research Laboratory in Temple, Texas.

Imported as an ornamental in 1837, saltcedar clogs thousands of miles of western streams. "It has almost taken over the Pecos and Brazos Rivers in west Texas, Rio

On Camera, Researchers Capture The Beast—All 924 Acres of It

Some of the peskiest creatures on Punta del Monte Ranch are wild pigs that compete with cattle for the range forage. But because they're popular game among hunters and favored at barbecues, the wild pigs are considered a net plus.

That can't be said about a different ranch-devouring critter: false broomweed, nicknamed The Beast.

Last summer, The Beast became the quarry in the toughest trials yet of ARS airborne video. The research mission: Map the territory taken over by the weed at the ranch, an 11,000-acre spread north of Raymondville in south Texas.

"I guess the best thing about this weed is, it only grows a couple of feet tall. But where it grows, nothing else will," says Dan Butler, who operates Punta del Monte with his brother Richard.

Cattle won't eat false broomweed; it quickly pushes out native forage plants, and it resprouts readily despite chemicals, burning, and a variety of mechanical measures.

"Actually," says Dan Butler, "a lot of things work on it—until the next year, when it just comes back."

"For the Butlers, the news from last summer's study has not been good, but we're confident it's accurate," says James Everitt, who heads ARS Remote Sensing Research. "We found that the weed covers 8.4 percent—924 acres—of the ranch. Ground mapping of the entire ranch gave a close correlation—7 percent."

Nine hundred acres of grazable forage can support 40 to 90 cattle.

The brothers' ranch is the only one in the United States that's the subject of a complete, computerized multispectral video map, Everitt says.

First, researchers had to decipher the weed's video signature—its unique light-reflecting properties. They determined that the near-infrared filter would get the best video fix on the weed.

After mapping the ranch at about 10,000 feet, they used image-processing software to create a digital mosaic. Any scene on the mosaic can be accessed by punching its coordinates into the computer—the process is somewhat like using grid points to find a city on a road map.

Everitt says the findings could help the Butlers direct aerial applicators

Grande in central New Mexico, Gila and Salt in Arizona, and Lower Colorado between California and Arizona. It's gone north as far as Montana," DeLoach says. Besides robbing the dry land of precious water—3 to 5 feet per year—thickets of this Middle Eastern native make a stream channel less able to carry storm flows. The channel collects sediment, making floods more frequent and widespread.

"But with video," he notes, "we have a tool that makes it feasible to find out how much saltcedar we have and how important and effective a solution might be. In late fall, saltcedar leaves turn a unique golden-orange color that makes the plant—even individual trees—easy to spot from the air. The images can be turned into computer data showing the area covered by saltcedar."

Chemical or mechanical control is difficult and time consuming. DeLoach, an entomologist, wants to find, import, test, and release the tree's natural enemies—insects or microorganisms. Airborne video could help monitor the effectiveness of biological controls for saltcedar and other pests, he says.

Everitt says research has laid at least some of the groundwork for other potential applications of airborne video, including:

- Range and pasture forage growth, so stocking rates for grazing animals can be adjusted.
- Changes in the makeup of range plant species in response to weather and grazing practices.
- Damage from herbicide drift.
- Nutrient deficiencies in alfalfa, corn, cotton, and other crop and range plants.
- Overall crop vigor and production both in this country and less developed ones having few or no facilities for processing aerial photo film.

"The hardest part," he says, "is knowing how a plant or a pest or whatever gives itself away to the camera." Once research establishes these facts of light, modern video and computer technologies take over.—By **Jim De Quattro**, ARS.

James H. Everitt, Charles Cook, David E. Escobar, Noel Garcia, Rick Villarreal, Juan R. Noriega, and Rene Davis are in the USDA-ARS Subtropical Agricultural Research Laboratory, 2413 E. Highway 83, Weslaco, TX 78596 (512) 968-5533. Jack DeLoach is at the USDA-ARS Grassland, Soil, and Water Research Laboratory, 808 East Blackland Rd., Temple, TX 76502 (817) 770-6520. To reach others mentioned in this article, contact Jim De Quattro, Room 336, Bldg. 005, BARC-West, Beltsville, MD 20705 (301) 344-3648. ◆

who put down weed-killing chemicals. Future video coverage, he adds, could tell the rate of control—or further spread—of the weed.

The Butlers—cooperators with ARS and Texas A&M researchers for many years—would like to try using the weed's natural enemies. But no such suitable insect or pathogen has yet been identified.

"I feel bad that the new information, while it's vital to testing the technique, probably isn't going to help the Butlers and other ranchers much, right away," says Everitt.

"But by letting us fly over, walk over, and drive through their land, they're helping us carry out research that may lead to a workable solution."—By **Jim De Quattro**, ARS.

JACK DYKINGA

David Escobar (left), Punta del Monte Ranch foreman Espidio Salinas (center), and James Everitt examine a false broomweed plant. (K-3932-17)

A Rainbow of No-Wrinkle Cotton

Scientist are dyeing to improve no-iron fabrics.

Rob Reinhardt, Gene Blanchard, and Bob Harper are creating a whole new coloring book—one that will delight the textile industry and fashion-conscious consumers who like the soft touch of cotton but don't like the wrinkles.

These three ARS chemists aren't spending their time with wax crayons. Their medium is a variety of techniques that allow cotton to be dyed after it has been treated with a no-wrinkle finish. The techniques open the door to a broader range of patterns and more vibrant shades for consumers, while also saving industry money. And they don't reduce the breathability, absorbency, and comfort of cotton, says Reinhardt.

Currently, cotton fabric has to be dyed before a no-wrinkle finish is applied because the chemical bond created by the finishing process repels dyes. "The cotton fiber has to swell to accommodate the molecules of dye," explains Blanchard. "Once the fabric is heated and treated with a no-wrinkle finish, it won't accept those molecules as an untreated fabric would."

This puts the textile and garment industries between a rock and a hard place trying to keep up with the unpredictable and ever-changing fashion world. If textile manufacturers want to produce a wrinkle-free fabric, they first have to dye it and hope the colors will be "in" next season. If garment makers don't want to chance being stuck with a large inventory of "out" colors, they buy bleached, untreated fabric that can be dyed in the latest hues before or after the garment is made. As a result, consumers have a limited selection of wrinkle-free cotton garments on store racks.

But Reinhardt, Blanchard, and Harper have developed techniques that allow industry to apply a no-wrinkle finish to cotton fabric—both broadcloth and knits—before dyeing. Based at ARS' Textile Finishing Chemistry Research Unit in New Orleans, they have added to the no-wrinkle finish solution a variety of quaternary ammonia salts, also found in products such as chicken feed and fabric softeners. By adding a positive charge to the fabric, the modified finish attracts dyes, allowing no-wrinkle cotton to be dyed.

The New Orleans scientists are also looking at derivatives of triethanolamine—a chemical found in some hand lotions and shampoos—to add to the no-wrinkle finish formula.

The new techniques should increase cotton's marketability against synthetic fibers. Several patents have been issued on this technology, and other patent applications have been filed. Some of these techniques are currently being evaluated by the textile industry.

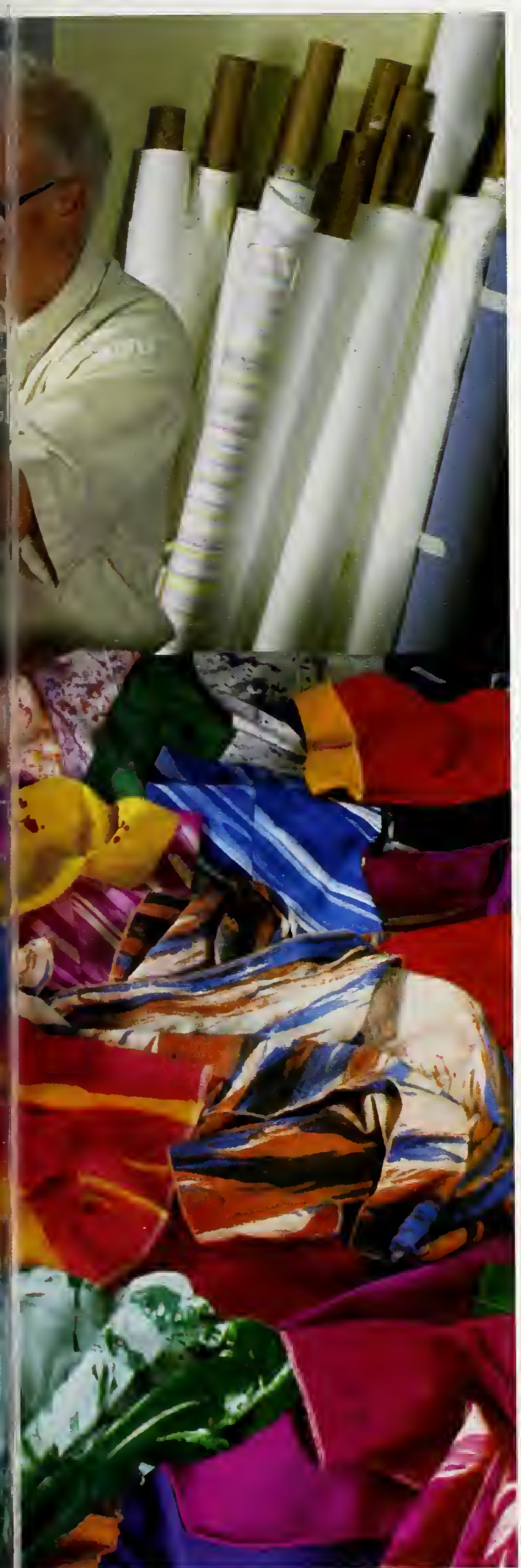
The modified finishes do more than enable industry to broaden use of no-wrinkle finishes without losing money to a fashion color change. They also broaden the choice of dyes that can be used, giving the industry more options for supplies as well as a wider range of shades and deeper, more vibrant colors.

Only certain classes of dyes—direct, reactive, and vat—can be used on untreated cotton fabric, Reinhardt says. However, the additives in the modified finishes have a positive charge, which attracts the acid dyes now used to color wool and nylon. Shades that can't be gotten with standard cotton dyes may be possible with acid dyes. What's more, he adds, in some cases the modified finishing process improves uptake of standard dyes, resulting in deeper hues.

Blanchard says washing tests have shown that fabric dyed by the modified process retains color as well as non-finished fabric. In some tests, it was even more color-fast.

PERRY A. RECH

Colorful, dyeable smooth dried cationic cotton fab (K-3837-13)



...re examined by chemist Robert Harper, Jr.

For those popular stone-washed and ice-washed jeans, the group's research can make it more cost-effective to produce a no-wrinkle garment. To achieve the irregular stone-washed look, industry now puts dyed garments in a tumbler with porous volcanic rocks called pumice stones. The stones wear down the fabric, creating an irregular pattern. In ice-washing, the garments are tumbled with stones that have been soaked in bleach to create a similar irregular pattern.

"This all might sound a bit wild," says Harper, "but then, who would have thought that stone-washed jeans would have become so popular?"

In some tests, the modified no-wrinkle fabric was even more color-fast than non-finished fabric that had been dyed conventionally.

Harper and co-workers have also used the modified finish to create a "mock denim" that gives the industry a shortcut in making denimlike fabric. To make real denim, dyed yarns are cross-woven with white yarns.

The new technique shortens this process into one dyeing step. This is done by placing large screens, normally used to print designs on fabric, on top of undyed fabric. When the modified no-wrinkle finish is applied through the screen, it contacts only the raised yarns. After the fabric has been heated, the treated yarns—those that run lengthwise—hold a positive charge and will accept dyes. Yarns that run crosswise don't have a charge and will not accept dyes. Finally, the fabric is dyed to create the denim effect.

Harper says, "this technique gives industry more versatility in jeans' color." Rather than committing to thousands of yards of blue yarn, for instance, textile manufacturers can use undyed yarn and produce a generic treated fabric that can be dyed any color they want.

Another finishing approach for unique design in a large-scale dyeing operation. This is done by modifying a textile finishing machine with lace to give an uneven application of the finishing formulation to fabric. Then, when the fabric is dyed in a dye bath, only the positively charged areas take the color, resulting in the design. The researchers have also devised ways of achieving multicolored fabric. These are based on either changing dye-bath pH in order to dye treated areas of the fabric with one color and untreated areas with another color or by using different agents that either remain on the fabric surface or penetrate deep into the cotton and respond to different classes of dyes.

And to achieve the effect of hand-dyed, tie-dye shirts, Harper and co-workers have found a way for the garment industry to do it for the consumer. They call this technique "rope finishing." Fabric is twisted in a ropelike fashion and subjected to a modified finish.

After the fabric is finished, it is untwisted, spread flat for drying and curing, then dyed. Only the finished areas of the fabric will accept dyes.

These new dyeing techniques allow the clothing industry to be more responsive to consumer demand.—By **Bruce Kinzel,** ARS.

Robert M. Reinhardt, Eugene J. Blanchard, and Robert J. Harper, Jr., are with the USDA-ARS Textile Finishing Chemistry Research Unit, Southern Regional Research Center, P.O. Box 19687, New Orleans, LA 70179 (504) 286-4521. ◆

The Mystery of the Sexual Jungle Fungus

He trudges through the tropics of South America and brings back fungi. Lots of fungi. More than a thousand specimens from a month spent in French Guiana. And then there was that other trip—yes, the one where he brought back the probable solution to the *Trichoderma* fungus mystery.

It's been a good trip if Gary J. Samuels returns from South America with a suitcase full of fungi that are new to science or that have potential uses in biological control. These beneficial fungi may naturally kill those fungi that cause plant diseases.

"Besides being biological controls, fungi have a very important place in the ecosystem," he says. "They degrade organic matter, serving as nature's recyclers to provide nutrients from dead organisms for use by living plants. Without them we'd be waist deep in dead wood, manure, and other detritus."

Samuels, a mycologist (fungus scientist) with the Agricultural Research Service, brings back both living and dried specimens of fungi to the Systematic Botany and Mycology Laboratory in Beltsville, Maryland. There he catalogs them.

To be able to catalog the specimens, he has to identify them by species. And in order to properly identify fungi, he has to determine how alike or different they are from one another.

And herein lies the mystery of the *Trichoderma* fungus.

Most fungi reproduce asexually, meaning the spores they release from the fruiting body (the part we see) are all alike. Since each generation is like its parent, taxonomists—scientists who specialize in identifying organisms—have used their morphology (what they look like) to tell these fruiting bodies apart.

But in addition to the asexual bodies, *Trichoderma* also have a form that produces microscopic sexual spores with genes that have recombined. So different are the two forms that 100 years ago, when the fungus was first found, the two forms of spores—sexual and asexual—were classified as belonging to different species of fungi.

Fungi such as *Trichoderma* are dear to agricultural scientists because they can help control diseases that are caused by other fungi. For example, when painted onto the pruned areas of fruit trees, one species can control the development of the fungus that causes silver leaf disease of stone fruit.

Samuels identifies *Trichoderma* by its morphology, providing other scientists with needed information to study its value as a biological control. These researchers in turn will study the chemicals these fungi produce such as enzymes, toxins, or antibiotics. They may even distribute the fungal spores in soil, in very much the same way fungicide might be distributed, and see how well they control pathogenic fungi.

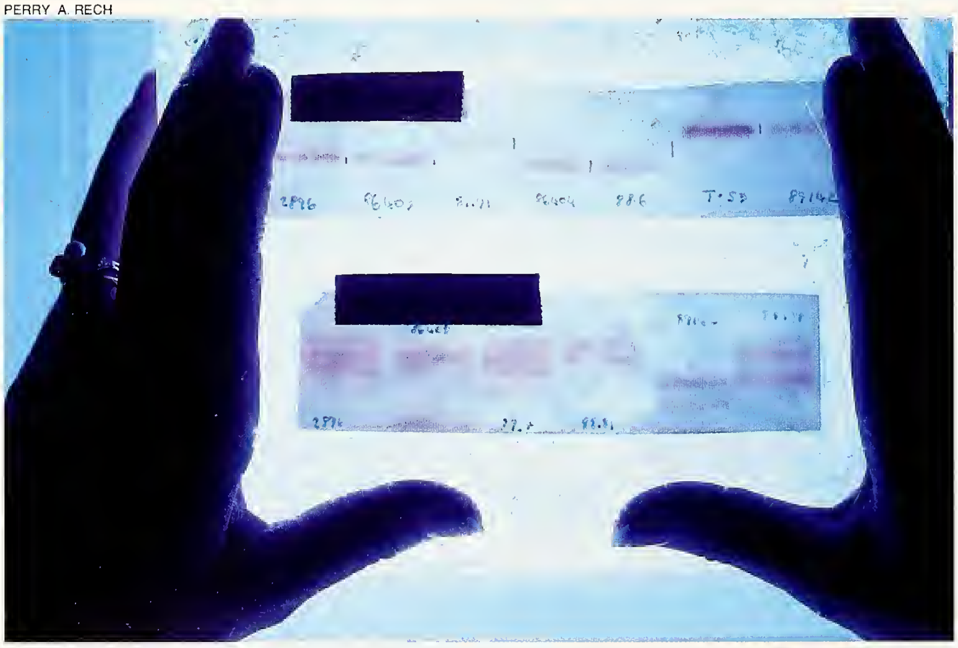
In the soil, beneficial fungi work in one of three ways: They are parasites and kill the pathogenic fungi outright, they produce chemicals that are toxic to the pathogens and so protect plant seeds, or their physical presence prevents the development of harmful fungi by simply using up all of the nutrients.

From three trips to South America, Samuels brought back the sexual stage of a species of tropical *Trichoderma*. But when he grew out the spores in the laboratory, they produced the asexual stage of the fungus. Since these cultures have recombined genes, they should have had different characteristics.

But could they be completely different species?

Collections made throughout the world show there is only one species of *Trichoderma*—when it is defined by the morphology of the sexual stage. But the asexual stage that came from the laboratory-grown sexual stage shows great morphological variation.

PERRY A. RECH



Following electrophoresis and staining, the number and locations of red-stained bands give an indication of the number of species of *Trichoderma*. (K-3811-2)

PERRY A. RECH

Entomologist Sylvie Manguin prepares enzyme extracts from *Trichoderma* in preparation for electrophoresis. (K-3812-6)

What kind of differences does it take to make up a separate species, anyway? The answer is not as cut and dried as one might expect.

"The questions are: Which morphological characteristics are reliable? Which should we base our species on, especially if we only have one stage, usually only the asexual *Trichoderma*?" asks Samuels.

Samuels and colleagues are taking a unique approach—using biotechnology to look inside these fungi—to figure out whether the asexual and sexual *Trichoderma* really should be depicted as the same species.

Robert J. Meyer, a research associate also with the laboratory, is checking the fungus' DNA to identify patterns that could serve as a "fingerprint" for each species of *Trichoderma*.

He has been examining a part of the total DNA, called ribosomal DNA (rDNA), that carries instructions for part of the machinery that makes the fungus' proteins. Meyer treats the rDNA with enzymes and then examines it on agarose gels.

The rDNA produces characteristic patterns on the gels that vary according to the strain of fungus the DNA came from. Using these patterns, a computer program determines the similarity of the strains and diagrams them in a "tree" by how closely they are related.

"The rDNA separates strains that are different morphologically," says Meyer. "But these rDNA characteristics are more sensitive indicators than the morphological ones because the rDNA patterns also group the strains at the sub-species level.

"The DNA studies have done what could not be done by other methods: Link strains for which the sexual stage was unknown to strains that were derived from the sexual stage," he adds. "This is an important step in clarifying the taxonomy of *Trichoderma*. Ultimately, the DNA patterns could be used to identify a strain regardless of whether it came from the sexual or asexual stage."

A visiting entomologist from France to Beltsville's Beneficial Insects Laboratory has also been drawn into the problem. Silvie Manguin is checking out the enzymes the fungus produces; she's found that some of these enzymes can inhibit the development of other fungi—possibly making *Trichoderma* useful as a biocontrol against harmful fungi.

Using starch gel electrophoresis, she is also determining the genetic variation among the *Trichoderma* species. These variations are expressed by differences in the amino acids that make up each of the 24 enzymes she tested.

"Related species of fungi can have slight differences in the sequences of their amino acids," says Manguin. "From these differences, I am creating a cladistic tree—a schematic that tells how closely related they are.

"My results, so far, have been similar to Meyer's," she adds. "Samuels found that morphologically these were closely related, and the DNA and enzyme studies are helping us clarify how close."

"The more characteristics we have to identify the *Trichoderma* fungi, the easier it is," says Samuels. "Because we have three detectives on the trail, we've got a whole other suite of characteristics that we can use for classification."

PERRY A. RECH

In the Herbarium of the National Fungus Collection, Gary Samuels studies specimens of fungi growing on sticks. (K-3810-8)

"This particular *Trichoderma* is a known species," says Samuels. "Next we will look at a soil-dwelling species where we don't yet know about its sexual stage.

"Our goal is to see if DNA and enzyme studies are also good techniques to identify fungi," adds Samuels. "For example, is spore color really an important characteristic to identify a fungus? It may turn out that spores of each color produce the same enzymes, and therefore the color isn't a good way to identify fungi."

Isolates of the *Trichoderma* are kept at the laboratory in Beltsville for further studies. The rest are sent to the American Type Culture Collection in Rockville, Maryland. About 100,000 species of fungi have been described by taxonomists; an estimated 200,000 exist worldwide.—By **Dvora Aksler Konstant**, ARS.

Gary J. Samuels is at the USDA-ARS Systematic Botany and Mycology Laboratory, Bldg. 011A, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-2279.

Replacing Fumigants With Beneficial Insects

Three cheers for the tiny heroes who stand guard at the granary!

Not all insects in stored grain are bad. In fact, Agricultural Research Service scientists have found that some wasps and predator bugs can be used to help wipe out the bad bugs. These beneficials could become a new way to control stored-grain pests while reducing the use of chemical fumigants.

A task force made up of U.S. Department of Agriculture, Environmental Protection Agency, and Food and Drug Administration personnel has prepared a proposed regulation that would allow parasites or predator insects of stored-product pests to be added to grain or used to control infestations in structures such as warehouses. This proposal was published in the Federal Register January 3, 1991 and EPA requests comments before March 4, 1991.

The proposed regulation would make the use of beneficial insects subject to the Federal Insecticide, Fungicide, and Rodenticide Act and exempt them from the requirement of a tolerance in food products.

The FDA would continue to use its criteria for enforcement of insect fragments in food. USDA's Federal Grain Inspection Service is responsible for inspecting and grading the grain.

The proposed rule is based on results of lengthy research at ARS' Stored-Product Insects Research and Development Laboratory in Savannah, Georgia.

"We are looking at specific parasites and predators of specific pests," says John Brower, a research entomologist at the Savannah lab.

NOAH PORITZ

Above: A lesser grain borer (*Rhyzopertha dominica*) emerges from a kernel of triticale after hollowing it out. (K-3965-1) Center: Population unchecked, a few lesser grain borers have become a horde. A female can lay up to 500 eggs, spreading 1 or 2 per kernel of grain. (K-3965-17) Below: All that the borers have left behind: empty triticale shells and frass-mingled debris. (K-3965-19)

"The advantage here is the insects are a biological, nonchemical control method."

Fumigation can be used to kill insects that infest stored grain, but fumigation doesn't solve the problem of commodity damage, Brower says. The damage caused by insects as they develop can't effectively be checked solely by fumigation. Instead, a preventive approach is needed.

Insects known as primary pests begin their destruction of grain after eggs hatch and the larvae bore inside individual grain kernels. Once inside a kernel the insect begins its development from larva to adult by feeding on the inside of the kernel.

By the time these insects become adults, they have completely devoured the inside of the kernel and then they chew their way out, Brower says. As each insect develops to adulthood and reproduces, infestation becomes a numbers game.

Three of the primary targets being studied by Brower and colleagues are the granary weevil (*Sitophilus granarius*), rice weevil (*S. oryzae*), and lesser grain borer (*Rhyzopertha dominica*).

All three pests attack wheat, rice, corn, and other cereal crops. Brower says these three insects can be found on grain debris in empty bins. When new grain is added to the bin after harvest, the insects begin their rapid growth and destruction.

Usually the weevils lay one egg per grain kernel. One insect can lay up to 300 eggs.

"This is what most people don't think about," Brower says. "They

NOAH PORITZ

Adult (top) and nymph warehouse pirate bug (*Xylocoris flavipes*), an insect so fierce, it will kill and eat any insect that it can subdue, including its own kind. (K-3966-1)

continue to multiply; it's like a chain reaction of population growth."

The lesser grain borer can lay up to 500 eggs per female insect with one or two eggs per kernel of grain. The lesser grain borer is particularly bad because it continues to feed after it reaches adulthood.

"It's just a continuous eating machine," Brower says. "It literally turns grain into dust."

The damage created by the lesser grain borer and the two weevils opens the door to a host of moths and other insects that continue to damage stored grain.

Even though grain is cleaned and inspected with rigor, insects can cause problems when grain is processed into products such as flour, Brower says. For example, when all the external insects are removed, some of the primary pests inside grain kernels are missed and ground into flour, he says.

"The flour may then have to be condemned," Brower says. "It is difficult to remove these primary feeders; they are inside the kernels."

Brower says releasing parasites of these primary insects that damage grain seems to be the best answer. These parasites have only one selection on their menu, and that selection is the damaging insects within the kernels.

"We are looking at specific parasites of the *Sitophilus* weevils," Brower says. "These beneficial insects can be raised on host weevils and then released onto grain."

One of those parasites, called the *Anisopteromalus* wasp, is already showing promise as an effective control of weevils in wheat. Brower says the female *Anisopteromalus* crawls through grain until it finds a kernel that is infested by a pest.

When the kernel is spotted, she drills a hole and lays an egg. The egg hatches on the outside of the larva of the stored-grain pest, and the parasitic insect feeds on the body fluid of the larva.

"We don't know how the parasite can tell which kernels are infested," Brower says. "Maybe it smells the host or maybe it hears it."

Brower says it completely consumes the larva within a week. The parasitic insects are very efficient at finding insect pests—even when present in small numbers.

"Every one they find, they destroy," he adds. "But when they run out of food, they die quickly."

The dead beneficial insects that have helped control pest populations in stored grain are easily cleaned from grain, Brower says. The parasites will never evolve to the point that they develop their own taste for grain.

But being so specialized can also be a disadvantage. This trait makes it difficult for scientists to find one insect that can attack all types of stored-product pests.

Brower says scientists are working to answer "just how many beneficial insects would be needed to control grain pests on a large scale?"

Most of the tests at the Savannah lab have been in small storage situations. For example, in warehouse rooms containing *Sitophilus*-infested grain debris, 30 pairs of *Anisopteromalus* reduced weevil populations by 90 percent and 50 pairs reduced them by 95 percent.

Brower says scientists aren't looking at beneficial insects as the sole answer to the problem. Instead, they are working on an integrated biological and chemical program

NOAH PORITZ

Entomologist John Brower releases adult warehouse pirate bugs for tests in a grain storage bin at the research center in Savannah, Georgia. (K-3961-3)

NOAH PORITZ

Anisopteromalus calandrae, a parasitic wasp of the rice weevil and lesser grain borer, lays an egg inside a weevil-infested kernel of corn. When the egg hatches, the parasitic insect will feed on the body fluid of the weevil larva. (K-3962-1)

that includes proper sanitation and insect-tight grain storage facilities as well as tight controls on factors such as temperature, ventilation, and moisture within grain. This integrated biological control system could eventually greatly reduce fumigation.

"Until we can answer the question of how this will work on a large commercial scale, we really can't recommend a correct insect-release rate," Brower says. "We have been working with ARS' Rice Research Unit at Beaumont, Texas, on combining both chemical and biological controls to reduce grain infestation in bin-stored rice."

NOAH PORITZ

The rice weevil (*Sitophilus orzae*) on a kernel of triticale. One insect can lay up to 300 eggs. (K-3968-1)

At the end of a 15-month test, rice weevil populations were reduced by 67 percent and lesser grain borers by 89 percent. Populations of some secondary pests, such as the flat grain beetle, were reduced as much as 97 percent, Brower says. Scientists at ARS' Biological Research Unit in Manhattan, Kansas, are also working with parasites of those pests that don't develop inside grain kernels, or secondary pests.

A good one-two punch for control involves using predatory insects to "come in and clean up" what the parasites don't eat, Brower says. One of these predators is the warehouse pirate bug, *Xylocoris flavipes*. This predator eats eggs and larvae of secondary pests. The warehouse pirate bug is so fierce that it will kill and eat any insect that it can subdue—even its own kind.

A practical way to prevent infestation of stored grain is to release predators in empty grain bins before harvest. These predators find the nooks and crannies where old grain is trapped and destroy any insects present. "They'll hunt out and find those residual insects—knocking out that population," Brower says. "What you're doing is preventing that new grain from becoming infested from any old grain left in the bin.

After a crop is harvested and new grain is put in the bin, "there should be periodic releases after harvest," he adds. "This may solve the problem."—By **Bruce Kinzel**, ARS.

John H. Brower is with the USDA-ARS Stored-Product Insects Research and Development Laboratory, P.O. Box 22909, Savannah, GA 31403 (912) 233-7981. ◆

Linguine and Nematodes?

A lot of noodling around went into this new concept in biocontrol.

While it might not be an appealing Italian dish, a pasta combination that uses nematodes may curb insect damage to crops, plants, and lawns.

Or if you want to control weeds instead of insects, a mixture with fungi is an effective weed control formulation.

Agricultural Research Service scientists who developed this combination call it Pesta. Researchers found that when durum wheat flour called semolina—the same flour used to make pasta—is mixed with either nematodes or fungi, the result is an effective biological control of insects and weeds.

"The process is simple and relatively inexpensive," says William J. Connick, Jr., a research chemist with ARS' Composition and Properties Research Unit in New Orleans. "It can be carried out at room temperature, and it's not going to expose the people using it or handling the product to dangerous materials."

Connick obtained the biocontrol organisms that target specific insects and weeds from ARS zoologist William R. Nickle and plant pathologist C. Douglas Boyette. He blended a mixture of wheat flour, clay powder, and ingredients that benefit the organisms with a water slurry of either nematodes or fungi at Connick's lab at the Southern Regional Research Center in New Orleans.

After the mixture is kneaded, nematodes or fungi are trapped in a dough. Connick rolls out a thin sheet and dries it overnight at room temperature.

"The next day the dry dough is stiff and can be easily ground up," Connick says. "To get granules of about the same size, we sifted them through sieves."

Boyette and Nickle have tested the performance of the new Pesta biocontrol products.

Against hemp sesbania, a weed commonly found in soybeans, rice, and cotton, Boyette found that Pesta containing the fungus *Colletotrichum truncatum* completely wiped out the weed population within 7 days of application in greenhouse tests. Pesta containing other weed-killing fungi was tested against sicklepod and jimsonweed with promising results.

Pesta with *Steinernema carpocapsae* nematodes was tested against corn rootworm larva. Twenty-one days after greenhouse application, Nickle saw a 63 percent reduction in emergence of adults. These products may also be useful for controlling other soil insects.

Tests were conducted under environmental conditions conducive to activating either the nematodes or fungi in the granules.

"The nematodes start coming out soon after the granules get wet, releasing over 35,000 viable nematodes per gram into the soil where pest insects are present," Connick says. "After exposure to moisture and sunlight, the fungus grows and completely covers the granule like a fuzz, then releases spores, usually within 24 to 72 hours of application."

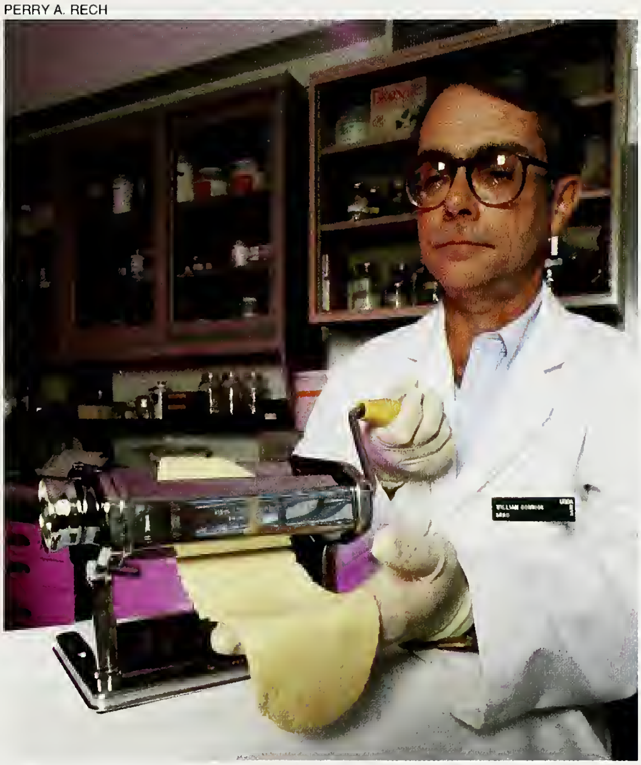
Connick is studying ways to improve Pesta's shelf life. He says when moisture-retaining chemicals are added to the formulations, they enhance the survival of nematodes during storage.

Currently, nematode granules will last at least 9 weeks with refrigeration. Fungi in pesta, however, can survive months at room temperature.

"Since the method is based on pasta production, knowledge on how to make these granules and equipment already should be available worldwide," Connick says. "And we're using renewable and biodegradable materials to make the Pesta products."—By **Bruce Kinzel**, ARS.

William J. Connick, Jr., is at the USDA-ARS Composition and Properties Research Unit, Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124 (504) 286-4527. William R. Nickle is at the USDA-ARS Nematology Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-3064. C. Douglas Boyette is at the USDA-ARS Biological Control of Weeds Research Unit, Jamie Whitten Delta States Research Center, P.O. Box 350, Stoneville, MS 38776 (601) 686-6253. ◆

PERRY A. RECH



Chemist William Connick, Jr., rolls dough containing semolina mixed with *Steinernema carpocapsae* nematodes to make Pesta, a biological control product. (K-3841-3)

Ancient Forage Found Useful

By the time George Washington brought sainfoin to the United States, it was already an old forage—as ancient as the legends that name it as the bedding in the manger at Bethlehem.

But Washington couldn't make the Mediterranean legume flourish at Mount Vernon. More than two centuries later, Agriculture Research Service agronomist Daniel P. Mowrey says it was the soil.

"Washington's sainfoin failed mainly because of the acid soils of the eastern United States," says Mowrey, who works at the ARS Forage and Livestock Research Laboratory at El Reno, Oklahoma. "It needs at least a pH of 6 and can grow well up to 8."

Sainfoin can also take heat, drought, and cold—a resilience that's sure to win the hearts of many a western cattle or sheep producer. Best of all, it doesn't cause bloat, a potentially deadly condition in livestock that is rightfully blamed on many legumes.

Bloat occurs when sugars in legumes break down during digestion in the grazing animal's rumen. The sugars create a gaseous froth that swells the rumen against the animal's lungs, causing suffocation.

Mowrey says sainfoin matches alfalfa in nutritional value, with crude protein of 15 to 20 percent.

But sainfoin speeds ahead of alfalfa in the spring, beginning growth in March to provide much-needed early, high-protein grazing until late June, when other forages are available.

Sainfoin's failing is in the area of nitrogen fixation. Legumes can transform nitrogen from the air into forms usable by the plant, easing the need for additional fertilization. But Mowrey says sainfoin's nitrogen fixation is sometimes less than stellar.

Producers usually give legumes a jumpstart in nitrogen fixation by inoculating them with special bacteria called *Rhizobium*. Now Mowrey is working with Agriculture Canada, Canada's federal agricultural research agency, on testing a newly discovered Arctic strain of *Rhizobium* that may overcome sainfoin's weakness. His are among the first field tests of the Arctic *Rhizobium*, although it has already performed well for other researchers in greenhouse studies.

In addition, Mowrey has completed the first year of grazing studies that show sainfoin persists well if about 30 percent of the plant is left for regrowth. Overall, he's optimistic about the legume's future in the western United States.—By **Sandy Miller Hays**, ARS.

Daniel P. Mowrey is in USDA-ARS Forage and Livestock Research, P.O. Box 1199, El Reno, OK 73036 (405) 262-5291. ◆

PERRY A. RECH

Chemist Gary List displays contrast between dark, low-quality soybeans damaged by weather and high-quality soybeans that can be processed with minimal oil refining loss. (K-3935-13)

Enzyme Causes Soybean Oil Refining Loss

Less salad or cooking oil may be processed from one shipment of soybeans than from another almost identical shipment. Why the difference? It's caused by a refining loss that could be avoided if the beans were not abused—handled roughly before reaching the processor.

Scientists have found that the main culprit in oil refining losses, especially in damaged beans, is an enzyme called phospholipase D that interferes with degumming—the first step in refining. Crude oils that are readily freed of phosphatides—lecithins, gums, and other fatlike phosphorus-containing compounds—produce high yields of refined oil more likely to retain fresh flavor, says Gary R. List, a chemist at ARS' National Center for Agricultural Utilization in Peoria, Illinois.

To degum, processors agitate a little water with the oil to hydrate phosphatides that can be recovered from the gums after centrifuging. Nonhydratable phosphatides (NHP's) formed by the workings of phospholipase D on phospholipids remain with the oil until further processing removes them. Accordingly, the enzyme may increase losses during oil refining from the normal 2-4 percent to 20 percent, depending mostly on how well the soybeans were handled before they were processed.

"As we began our study in 1987, we suspected phospholipase D was responsible and hoped to find a way to precondition soybeans before shipment or just before oil extraction to inactivate the enzyme," says List.

So far, that goal proves elusive but the study is helping the scientists better understand conditions and mechanisms that allow NHP's to form. A little microwave heating only made the enzyme more active, but enough microwaving to destroy the enzyme—8 to 10 minutes—was not economically practical. Pressurized steam treatment of soy flakes to a temperature of 235°F also worked but was expensive and damaged protein.

For now, List says, the only good way to keep phospholipase D activity low is to handle the soybeans gently at the lowest practical moisture.

Someday, refining losses from both high- and low-quality beans may be reduced through genetic engineering advances to thwart the enzyme's activity after harvest. The biotech approach also promises to improve the quality of finished soybean oil by eliminating enzymes called lipoxygenases. [See *Agricultural Research*, September 1989, p. 10].—By **Ben Hardin,** ARS.

Gary R. List is at the USDA-ARS National Center for Agricultural Utilization, 1815 N. University St., Peoria, IL 61604 (309) 685-4011. ◆

Increasing Cotton's Nonwoven Market

Chances are, the "cotton" ball used to remove the day's makeup is an imposter.

The cosmetic puff is just one of many nonwoven products where synthetic fibers, such as polyester, polypropylene, and rayon, have replaced cotton fiber. But ARS scientists are studying ways to make products with 100 percent cotton to improve on cotton's 4 percent share of the nonwoven market.

Nonwoven cotton fabrics are made directly from a mesh of fibers that are bound together by machines with needles or adhesives.

Cotton fibers must be cleaned of debris and bleached. This process removes natural waxes, so a lubricant finish must be applied to aid in processing. Better lubricants are needed for improved processing.

Synthetic nonwoven fibers can be processed faster than cotton, but industry is turning to cotton for other reasons.

"These days, the consumer wants a product that doesn't create environmental concerns," says Jerry P. Moreau, a research chemist at ARS' Textile Finishing Research unit in New Orleans. "Waste disposal, which is a major worry for users of synthentic nonwovens, would not be a problem with cotton. It's biodegradable," he points out.

Moreau has tested cotton biodegradability by placing fabric samples in sterilized trays and exposing them to soil fungi. Five types of fungi are used, and the fabric is exposed to controlled temperature and humidity. His results show that 100 percent cotton completely degrades after 14 days.

Biodegradability is not Moreau's only interest in cotton nonwovens. He thinks cotton's favorable properties of comfort, feel, softness, and absorbency lend cotton nonwovens to use as medical disposables such as hospital and surgical products.

Cotton nonwovens could also be used to make apparel, head rests, bibs, bed sheets, pillow slip covers, towels, wipes and even liners for computer floppy disks, he says.

Moreau is concentrating on disposable diapers, looking for ways to replace the synthetic coverstock (inside lining) of diapers with 100 percent cotton. Such an improvement in degradability would be a boon for the nation's landfills. More than 18 billion disposable diapers end up in landfills each year, according to a Kansas City firm that studies waste disposal.

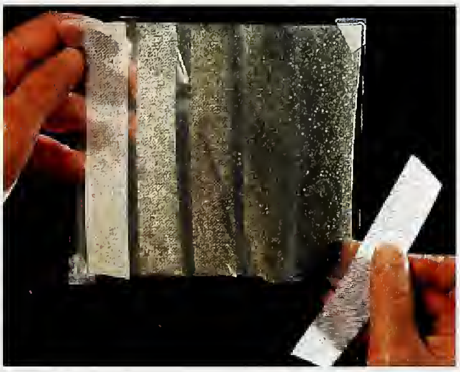
The main technique Moreau is using to make cotton nonwoven fabric is heat bonding. This process requires at least 10 percent synthetic fiber, which melts to bind cotton fibers.

However, other techniques—such as needlepunching and hydroentanglement—offer opportunities to make 100 percent cotton nonwovens. Needle-punching, one of the oldest mechanical ways of making nonwovens, binds fiber when notched needles move up and down, penetrating and entangling fibers.

Moreau says hydroentanglement "is the technique of the future." This involves high-pressure water jets to entangle fibers, resulting in fabric that closely resembles traditional woven cotton fabric.—By **Bruce Kinzel**, ARS.

Jerry P. Moreau is at the USDA-ARS Textile Finishing Research Unit, Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124 (504) 286-4331. ◆

PERRY A. RECH



Exposed to various soil fungi, cotton samples show varying biodegradability when blended with synthetic (polypropylene) fibers. Left to right: 25% cotton and 75% synthetic, 50%/50%, 70% cotton and 30% synthetic, 80/20 and 100% cotton. White strip is 100% synthetic fiber. (K-3842-3)

New Grasses Fulfill Many Needs

Dacotah switchgrass, Bison big bluestem and Tomahawk indiangrass are the three newest grass cultivars stemming from collaborations between ARS and Soil Conservation Service scientists.

These warm-season grasses were made available to meet the needs of the Conservation Reserve Program in the northern United States. They're good for range and pasture seedings, wildlife habitats, erosion control structures, revegetation of surface mines, and beautification along roads and waterways, according to plant geneticist Reed E. Barker.

Barker, who is with the ARS' Forage Seed and Cereal Research unit in Corvallis, Oregon, selected, developed, and tested the new grasses with scientists from SCS and state experiment station cooperators in Minnesota, South Dakota, and North Dakota. The original plants for the new varieties were collected in the 30's in North Dakota and South Dakota.

The new grasses, which grow well during the dry, hot season, could provide ranchers in the Northern Plains with a continuous supply of high-quality forage. Most ranchers rely on cool-season grasses that thrive in the spring and fall but are dormant or heat-stressed during summer months.

Being adapted to harsh growing conditions, Dacotah and Bison can thrive in low-fertility soils, like those on old mine sites or along roadsides. The dense sod these grasses produce helps to control erosion, as well.

In other natural areas, wildlife—mainly ducks, geese, and pheasants—can build nests with the vegetation and eat seeds from all three grasses. The tall (3-5 feet), bushy plants also provide camouflage for the birds.

The USDA-SCS Plant Materials Center, P.O. Box 1458, Bismarck, North Dakota, has seeds of the new cultivars for sale or can refer potential buyers to commercial seed sources.—By **Julie Corliss**, ARS.

Reed E. Barker is at the USDA-ARS Forage Seed and Cereal Research Unit, 3450 S.W. Campus Way, Corvallis, Oregon 97331-7102 (503) 757-4728. ◆

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